UtahState
UNIVERSITY

8200 Old Main Hill
Logan, UT 84322-8200
435 797-3229
david.stevens@usu.edu

Nadim Zeywar, Ph.D.
TMDL Unit Chief
Colorado River Basin
Regional Water Quality Control Board
73-720 Fred Waring Drive, Suite 100
Palm Desert, CA 92260

Dear Dr. Zeywar,

I am pleased to attache my review of the Draft New River Dissolved Oxygen (DO) Total Maximum Daily Load (TMDL) proposal. As you will note, I have tried to address each of the questions requested in your cover letter of November 14, 2008. If you have any questions or concerns with this review, please contact me at the above address, phone, or email. It's been a pleasure working with the State of California and the Colorado River Basin Regional Water Quality Control Board and I look forward to the possibility of future service.

Sincerely,

David K. Stevens, Ph.D., P.E.
Head, Environmental Engineering Division
Department of Civil and Environmental Engineering
8200 Old Main Hill
Utah State University
Logan, UT 84322-8200

Attachment
cc: F. Costa, CRBRWQCB

New River TMDL
Draft Peer Review

December 15, 2008

Introduction

The following is a review and assessment of the New River (CA) TMDL to restored dissolved oxygen for aqueous habitat in the U.S. reaches of the New River. The primary causes of low oxygen levels appear to be high biochemical oxygen demand (BOD) in the river at the U.S./Mexico border as the river leaves the urban area of Mexicali, Mexico and flows northward into the Salton Sea, near Calexico, CA. Though some improvement in dissolved oxygen levels have been achieved since December 2006 with the first phase of the TMDL implementation plan, though more organic matter and ammonia load reductions will be required to meet the 5 mg/L standard over the entire 120 km reach from the border to the Salton Sea.

After data were collected, the QUAL2K model was populated and executed to find conditions with the potential to meet water quality standards. The model runs showed that large reductions in BOD and ammonia at the international border coupled with similar reductions in waste water discharge BOD and ammonia from point sources in the U.S. reach and the addition of in-stream weirs to raise the DO in situ.

This review will address the TMDL assessment effort with an emphasis on the QUAL2K model development, use, and interpretation of the results.

Executive summary and conclusions

This review addresses the **Draft Total Maximum Daily Load And Implementation Plan For Dissolved Oxygen For The First Twelve Mile Segment Of The New River Downstream Of The International Boundary** (November 13, 2008). This document was reviewed with respect to the scientific and engineering soundness of the material presented in the report, focusing on the specific issues set forth in the accompanying letter. The reviewer's main expertise is in water quality modeling and was asked to focus on that portion of the report, though the reviewer has been part of development of TMDL Load and Implementation plans for several western watersheds.

The review is organized according to the specific issues in the main body starting in the next section. The **Overarching Questions** posed by the board are addressed below.

Overarching Questions

a. In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific basis of the proposed rule not described above? If so, please comment with respect to the statute language given above.

At this stage of the TMDL process for the New River, it appears that the important scientific/engineering issues have been addressed in the draft report. It is clear that the primary issue of the New River TMDL is to obtain an agreement with Mexico to add to and improve wastewater treatment in Mexicali. The degree to which the wastewater is to be treated is a detail that will likely be negotiated with regard to the ability to pay on the part of the City of Mexicali, higher level support from the government of Mexico, and the ability and willingness to cost share on the part of the United States and the state of California.

The level of treatment recommended based on the modeling results is expensive and the negotiation is likely to be delicate. When that stage is reached, the modeling work will likely need to be revisited to recalibrate with more extensive data sets designed specifically for that purpose. It is one thing to calibrate a model with one or two locations along a long river reach - with so many parameters the water quality targets can be predicted more or less exactly with a variety of combinations of model parameters. This, however, does not provide an adequate test for future conditions. For example, if the load at the international border is reduced to levels required by the model, it is likely that the sediment oxygen demand (essentially assumed away in Attachment F) and algal respiration will become much more important factors. Since the model was calibrated to one set of conditions during one year and corroborated against a nearly identical set of conditions, the calibration should be considered as conditional pending a larger effort under more conditions.

b. Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

In the reviewer's experience the answer to this question is always 'no' because the burden of scientific rigor is never met in the TDML program. This is **not** intended as a criticism of the New River TMDL specifically. It reflects the political reality of the TMDL program generally and the consequences of this portion of the Clean Water Act having been neglected for so long after the Act's passage. The databases are inadequate generally because the states' ambient water quality monitoring programs were never designed to support TMDLs directly. This is particularly true in

cases in which modeling results are such an important part of the assessment and implementation plan design.

The 'Scientific' portion of the analysis is better termed 'Engineering' because in engineering we are often expected to make judgements and move forward **without** sufficient scientific knowledge and information to solve problems. That is the case here - and the conclusions of the sources of the oxygen demanding materials and what needs to be done, in principle, are sound because the dissolved oxygen problem is so critical and the reasons so obvious that engineering judgment is sufficient to identify and take the first steps to solve the problem. Once the major sources of pollutants are controlled the situation in the New River will change dramatically and only then will the modeling be useful for fine tuning the dissolved oxygen levels. As it stands, the model results are equivalent to 'back of the envelope' calculations leading to a conceptual design.

Summary

The New River TMDL is scientifically relatively straightforward. The dissolved oxygen is depressed in the upper 20 km north of the U.S./Mexico border to a degree that significantly impairs habitat for warm water fish. The primary reason for the low dissolved oxygen is the load from Mexico due to inadequate wastewater treatment resulting in high levels of oxygen-demanding materials (organic matter and ammonia) in the river at the Border. The QUAL2K model run under severe conditions reproduced oxygen sag in the first 20 km followed by oxygen recovery downstream to the Salton Sea. The TMDL implementation plan is properly focused on reducing the load at the International Border - the exact means for accomplishing this are less clear. The following conclusions are offered on the basis of this review.

Conclusions

1. The fundamental scientific basis of the TMDL report is sound, though, as with many TMDL reports, some of the key data are lacking and progress is made based on assumptions and scientific judgment.
2. The details of the modeling approach, calibration, and results are lacking in the report, making it difficult to review objectively. Though the QUAL2K model is appropriate for this type of analysis and general approach appears sound, more detail concerning the model parameters is needed.
3. Uncertainty analysis using the model would be welcome to help in implementation since important and expensive engineering decisions will be made on the basis of the results and important questions revolve around the likelihood of failure to achieve TMDL goals, and the identification of the model inputs that are most important in the implementation design.
4. Monitoring dissolved oxygen at a high frequency would help answer the question of the minimum DO, as required in the State of California water quality objectives.
5. Additional monitoring should be carried out to better calibrate and test the QUAL2K model.

Review of
Draft Total Maximum Daily Load And Implementation Plan For Dissolved Oxygen For The First Twelve Mile Segment Of The New River Downstream Of The International Boundary

1. Project Definition. This section describes DO impairment in the New River at the International Boundary. Low levels of (DO) in the water column threaten fish and wildlife communities that utilize New River habitat downstream of the International Boundary and violate New River's WQSs. A TMDL implementation plan to achieve WQSs is proposed. The TMDL implementation focuses on monitoring and controlling known causes of low DO from Mexico.

The primary causes of low oxygen levels appear to be high biochemical oxygen demand (BOD) in the river at the U.S./Mexico border as the river leaves the urban area of Mexicali, Mexico and flows northward into the Salton Sea, near Calexico, CA. Though some improvement in dissolved oxygen levels have been achieved since December 2006 with the first phase of the TMDL implementation plan, though more organic matter and ammonia load reductions will be required to meet the 'above 5 mg/L at all times' standard over the entire 30 km reach from the border to the Salton Sea.

Review. This section of the TMDL report is clear and unambiguous and reflects a real and long term problems in a straightforward way.

2. Data and Source Analysis. The source analysis for this TMDL identifies and quantifies natural and human-related Biological Oxygen Demand (BOD) and Ammonia (NH3) sources to the New River. Data and information used in the source analysis were obtained from the Regional Board, the United States Geological Survey (USGS), the Imperial Irrigation District (IID), the United States International Boundary and Water Commission (IBWC), Wastewater Treatment Plants, and others.

Review - Source Analysis. The section of the TMDL report is well done generally. In a couple of paragraphs some comments were ambiguous. The goal here is to point them out.

a. On p 23 paragraph 2 discusses **urban** runoff but then says that it is unlikely to cause problems because of high ET and the lack of urban area. Does this mean that the lack of urban land use limits the generation of urban runoff, or that urban runoff will not reach the New River because of the small urban area? One presumes the former but the statement is ambiguous.

b. p. 23 para 3 says the annual average rainfall is 2.5" but on p. 14 the average annual rainfall is < 3". These are consistent but why not one or the other consistently in the report.

The reviewer fully agrees with the final comment in the source analysis section that a continuous monitoring program is needed, especially give the large economic impact full implementation of the TMDL will have on the City of Mexicali and the U.S. partners that would presumably provide part of the funding for plant upgrades.

Review - Data Analysis.

Flow data- One curious issue concerns the water sources. At 500,000 acres and 2.5"/year rainfall, the steady state watershed yield is about 100,000 ac-ft or 140 cfs. The flow from the Mexico side is slightly more than 150 cfs for 2004-2007, yet only a small portion of the drainage area is physical in Mexico. It would be interesting to read about the water sources - interbasin transfers, groundwater pumping, sea water desalination and about the sustainability of the flows. The comment on p. 28 about the decreasing flows at the border appears to be based on the 2004-2007 dataset and 2008 appears to be headed toward an increase in flow. These short term fluctuations are common even when long term trends are steady. If a longer term record is used for this comment, it should be so stated. Then, what are the implications of the reduced flows?

Water quality data - Figure 4-2 demonstrates that water quality data, especially DO and temperature should come with time support and time metadata. Are these data grab samples, monthly means and if so of how many measurements? The November 2006 observation of > 12 mg/L jumps off of the plot and suggests that the observations were taken on a bright warm sunny day when algae are producing oxygen well in excess of saturation (12.21 mg/L is in Appendix E for 11/06 - the actual date/time are not given. One wonders if this isn't a typo - 2.21 mg/L seems more representative). How does this influence interpretation of the results. Since the time support is not given one wonders about the remaining data and whether the DO data are representative of in-stream conditions. Higher frequency monitoring would be valuable in making that assessment. That the DO is low and appears to jump after 2006 is clear - however the details are not.

3. Critical Conditions and Seasonal Variations. This section describes the critical condition/ seasonality with the strongest impact on organic matter loading. Identifying these conditions is important to achieve DO WQOs and TMDL numeric targets.

Review. This section seems to contradict Appendix F in which the TMDL scenarios were run for summer (worst case (IB temperature of 30.5°C, presumably summer), conditions and Table 4.1 and Figure 4.2 where we see that the lowest flows are in the summer at the IB and in the fall at the Salton Sea outlet. Because the critical condition assessment dictates the model results for the TMDL scenarios, unambiguous identification of these conditions is important. This should be clarified.

Specific comments/questions:

a. p. 31, para 2 - there the annual rainfall is stated as 3"/year - from 2.5 to < 3 to =3. Please clarify.

b. p. 31, para 4 - here it is stated that the highest concentrations are during the winter since the return flows are zero. Does this contradict the use of summer months for the model scenarios? Higher concentrations and lower flows are generally worst case, though higher oxygen solubility through lower temperatures mitigates this. Is the fact that DO is lower at the IB in summer correspond to this?

4. Numeric Targets. The numeric target for dissolved oxygen for this TMDL was developed to protect all beneficial uses of the New River, and is equal to the Water Quality Objectives (WQOs) set forth in the Regional Board's Basin Plan. To satisfy human health criteria and adequately protect aquatic habitats, management practices that reduce organic waste will be utilized to implement this TMDL.

Review. There are no real concerns with this section. However, there is some ambiguity between the stated WQO in

http://www.waterboards.ca.gov/coloradoriver/publications_forms/publications/docs/basinplan_2006.pdf

(see snippet, right), in which the standard clearly states the 5 mg/L or above is to be maintained **at any time**. Table 6.1 on p. 34 of the report from U.S. EPA guidelines has a duration basis and includes values at 3 and 4 mg/L for mature fish for a 1 and 7 day minimum. The criteria for early life stages are more protective so the 1 day minimum is the standard apparently adopted by the State of California. Perhaps a statement to that effect would clear things up.

F. DISSOLVED OXYGEN

The dissolved oxygen concentration shall not be reduced below the following minimum levels at any time:

Waters designated:

WARM ..... 5.0 mg/l

COLD ..... 8.0 mg/l

WARM and COLD ..... 8.0 mg/l

5. TMDL Calculation and Allocations and Linkage Analysis. This TMDL assigns allocations for BOD and NH_3 to all point and nonpoint sources of waste into the New River expressed as kilogram per day, to ensure protection of beneficial uses. These allocations were based on a QUAL2K water quality computer model that links BOD, NH_3, and DO, and was developed by Tetra Tech Inc. for the USEPA. Allocations are applicable to throughout the New River at International Boundary impaired designated segment drain system.

Review. The QUAL2K model of Chapra, Pelletier, and Tao (2006) was applied to the New River system under a variety of base case plus management scenario. On the basis of the findings, considerable effort is required for both the Mexico and U.S. sides of the border to achieve dissolved oxygen concentrations above 5 mg/L for the majority of the U.S. portion of the river with the assumed flow rates. The model review will address the population and use of the model.

Specific comments

a. p. 36, para 6 - Critical conditions were defined as low flow summer temperatures - this contradicts Table 4.1 where the low flows at the IB are in winter and at the Salton Sea where they are in the fall.

b. p. 40, para 1 - The comment about NH_3 as an indicator for anthropogenic eutrophication is misleading and confusing. In this context, its primary influence is that of an oxygen demanding constituent of waste water. Its influence on eutrophication is dependent on whether nitrogen is the limiting constituent or whether phosphorus, silica, or sunlight are limiting. Whether the nitrogen is in the ammonia form or is present as nitrate (after nitrification to reduce xoygen demand) is largely irrelevant from the eutrophication prespective. Ammonia's primary environmental effects are to reduce oxygen and to cause toxicity to fish at higher pH. Eutrophication is secondary. One admits that respiration by algae growth resulting from nutrients reduces DO at night and increases it during the day but the impact of NH_3 above rate limiting values for algae is minor.

c. The reviewer has never been a fan of the 'implicit MOS' via compounding conservative assumptions. At the end one doesn't know how large the MOS is - it may be huge, or it may be small. It's better to try to quantify the uncertainty. There was a workshop toward this end sponsored by EPRI (Robert Goldstein was the principal) at UCSB several years ago. There may be a final report to review.

d. Given the past rapid population growth in Mexicali, is the 2.6% annual rate reasonable? The INEGI (2001) reference in the reference list couldn't be found to check their assumptions. If New River flows are reduced at the border, that may just mean a higher BOD and lower border DO levels.

Review of Appendix F. Since Appendix F was provided separately, it is reviewed separately here.

Model Population

The model was populated with data from the NHD data set of the USGS (a reference to the data set should be provided).

Reach segments. The modeling group used 33 segments stating the this was the minimum required. No basis for this decision was given and should be provided. The reach lengths (assumed the same as segment lengths) ranged from 0.45 to 11 km in Table 2.1 (the report stated the range as 0.33 to 11 km, assumed to be a typographical error), with computational elements ranging from 0.45 to 2.75 km (dividing the reach length by the number of elements for each reach yields a range of 0.45 to 2.75 km, so the 0.33 km minimum reach is also assumed to be a typographical error).

Channel widths. Channel widths were interpolated between two known cross sections (report said extrapolated) and two additional cross sections at Lack Road and near Brawley (these couldn't be found on the maps provided). The meaning of the statement at the bottom of p.3 ("Additional measurements were obtained from the USGS based on recent flow data ....") is not clear - does this mean cross section data or flow data. One assumes cross section but it's not clear. Similar comments hold for the side slopes. It's claimed that consistent side slopes of 0.24 (assuming this means height/length) were found but never is it said how.

The above two points are probably minor in terms of the results - nonetheless, this sort of detail is important to provide a thorough review and for the results to be defensible through the public process.

Critical conditions. Questions concerning the critical choice of IB conditions (p.5)

1. Upstream IB BOD is a (the?) critical parameter.
2. How were the BOD data distributed? Was 50 mg/L the best representation, or just a convenient choice?
3. Reference to Setmire - what did Setmire observe. The reference is pointless as it stands and the next statement concerning the fluctuations doesn't follow.
4. Why choose the 3:2 split for slow/fast CBOD? How important is the choice?
5. Source of BOD decay coefficients? Data? Literature citations? Defaults?
6. Sources of other IB parameters, especially NH4/OrgN and phytoplankton?

7. Is the diurnal DO fluctuation important here or is the standard based on the steady state daily average? The standard on p 12 of the Draft TMDL report lists only that the water quality objective is a minimum of 5 mg/L but says nothing about the fact that the DO just before dawn is usually considerably lower than the average daily DO. In some states, the objective is to provide an average daily minimum DO above 5 mg/L. Is this not the case in CA? A quick glance at the Basin Plan can be viewed at: http://www.waterboards.ca.gov/coloradoriver/publications_forms/publications/docs/basinplan_2006.pdf

   and the following snippet was lifted from p. 12 for the water quality objectives for "all surface waters of the Colorado River Basin Region, with the emphasis on '... at any time', presumably referring to the lowest DO time of the day. Given this, unless it's being misinterpreted (no guidance was given in the TMDL report), at the high temperatures and obviously high BOD and nutrient loads, it is very likely that the DO fluctuations in the New River will drive the DO to very low levels at night when there's no photosynthesis even if the daily steady state average is at or above the WQO.

Tributary and wastewater inflows

It is stated in this section that the inflows and POTW discharges account for 2/3 of the flow at the Salton Sea but no mention is made of the time support for this statement. Presumably the POTW discharges are on the U.S. side of the IB and that the flows given are annual averages but reference is made to the USGS report (Setmire 1984) or 25 years ago. The tacit assumption is that the relative flows have not changed in 25 years. It's a little surprising that, in this day and age with such a high value agricultural area in a desert with almost no natural precipitation and a very large and growing metropolitan area in the headwaters, that the water is not accurately accounted for. In addition, given that low dissolved oxygen is not a new problem for the New River, it's surprising that so little is known about the contribution of the drains to the organic matter inventory in the river.

In Table 2-3, key - what is 'BPJ' used as a reference for estimated flow or water quality? Describe 'unusual or suspect value', the criteria used to flag them, and what was done in those cases.

Model calibration

Travel time. How were the travel times from 1984 scaled to match flow conditions in 2006? The authors state early on that the travel time is the critical physical measure for assessing oxygen behavior and yet the details of the travel time calibration are sketchy. The axes need to be labeled in Figure 3-1 - in fact they all need to be labeled in section 3.

Table 3-1 shows that Manning's *n* and side slopes were assumed the same for all reaches based on condition matching from Chow's classic open channel flow book - this is commonly done when hydraulic measurements aren't available. Channel slopes aren't given in the table. Again, the details of this are critical for understanding and the explanation that widths were obtained from GIS data but looking at the photo in Figure 2-2, because of riparian vegetation along the river banks simply measuring what appears to be open water would likely underestimate the width. Widths from the photos would be more closely related to the bottom width because the top edge of the bank is likely hidden under vegetation. Is this what was done? Or did the authors use GIS

polygon layers of the bank locations? It is difficult to see what actually was done to measure widths and no real description is given.

The choice of a constant Manning's *n* implies that the channel bottom conditions (substrate materials, presence of debris, flow characteristics, etc.) are constant over the entire reach from the IB to the Salton Sea. The reviewer hasn't visited this river but have worked on many Western U.S. rivers and this assumption seems to be a stretch. The authors don't mention adjustment of any of these parameters so one presumes that no adjustments were required to match the travel time.

Finally for the flow and other data, the data presented in the various tables have inconsistent units - sometimes cfs, sometimes cms, sometimes mgd. Though one realizes that different entities have difficult 'corporate' cultures when it comes to units, it would be very helpful if units were consistent throughout. It matters little which one, as long as they are the same. The same comment holds for use of SI vs. U.S. customary units (e.g. Figure 2-2 is temperature in ^{o}F but the flow in Manning's equation is in m^3/s). Again, choose one and be consistent.

Dissolved oxygen. The first statement in section 3.2 was that once the flow portions of the model were populated, the DO calibration was improved. This implies that calibration was attempted before doing so. Is this true? No mention of it is made previously. Then reference is made to Figure 33 (thirty three) - one presumes the authors mean Figure 3-3 (three dash three) on the next page.

The DO boundary conditions at the IB boundary were based on a measurement at the border - is this a single measurement (if so, at what time of day), or (more properly) an average over the day? Then authors then state that 'Despite additional drain and WWTP inflows of higher DO', asking the reader to believe that more pollutant loading should in fact improve to DO situation because the effluent is higher in DO than the river, and that '**carbonaceous** decay continues to deplete DO ...' with no mention of nitrification even though 3-4 mg/L of organic nitrogen plus ammonia are present in the loads from each of those sources (Table 2-3). Assuming that these nitrogen measurements are as N (the table doesn't say) and that nitrification consumes 4-4.5 mg O2/mg N, these nitrogen loads have an effective NBOD of 12-20 mg/L oxygen. Adding the 2-30 mg/L CBOD (again Table 2-3), the oxygen demand in these loads is 14 - 50 mg/L. One would hardly expect that the DO situation in the river would improve in light of these loads.

Figures 3-3 and 3-4 have legend items DO(mgO2/L)Min, DO(mgO2/L)Max, Minimum DO-data, and Maximum DO-data without description of what they are. In addition, my Figures 3-3 and 3-4 show now items on the plot that would be identifiable as Minimum DO-data or Maximum DO-data. Are they there? If not, remove the legend items.

At the end of this section mention was made of continuous DO and temperature data used to define a diurnal range for model input. Then the subject was dropped. What was done with this information? This is a critical issue for assessing compliance with the WQO.

In the DO calibration, as with travel time, no mention is made of any DO-related parameters that were adjusted. One presumes this means that the BOD decay and nitrification coefficients were taken from the literature or were defaults that came with the model. **These parameters are critical to the assessment and without their values, the model results cannot be properly reviewed.**

Uncertainty analysis

In situations where decisions are based on model results that rely on a number of assumptions and highly variable or uncertain inputs, uncertainty analysis is critical for estimating the likelihood that assumed critical conditions will be observed and the likelihood that the proposed management measures will have the desired result. It is especially important when extreme management measures are required to meet objectives.

Sensitivity analysis may be helpful, however, sensitivity analysis out of context (e.g. ± 0.5 CBOD in) as was presented here conveys little information about likelihood that either of those limits will be observed. The authors worked hard to find those conditions that would presumably meet the instream water quality objectives under the worst case - however it is impossible to know if those conditions will ever be seen and so, particularly in a delicate political situation such as a transboundary flow, the indicated conditions that would meet the standard, may be impossible to achieve.

One realizes that the QUAL2K model has no built-in uncertainty analysis capability. However, a first order uncertainty analysis can be coupled with the sensitivity analysis, and could help answer questions related to uncertainty.

6. **Implementation Plan.** - This implementation is different from other TMDLs because it relies on the assistance of U.S. Federal Government to deal with another country (Mexico). The implementation plan requests cooperation from Mexico to implement actions to prevent wastewater discharges into the New River in Mexicali from producing conditions that violate the TMDL.

Review. This is the most uncertain part of the TMDL in general, made more so by the international nature of the transbasin flows and water quality. Does the Board have any experience to draw upon to know whether the needed cooperation will be forthcoming from USEPA, USIBWC, and the Governments of Mexico and Mexicali? Without such assurances, it's going to be difficult to convince U.S.EPA that the implementation plan is viable. Cannot the Board or local entities carry out monitoring at the IB or is that politically too delicate to address without agreements from the U.S. and Mexico?

Section 9.4 has a threatening tone to it. Would the U.S. consider some type of sanctions against Mexico if they don't comply? Are there alternatives (e.g. the U.S. building a river water treatment plant for a portion of the flow near the border to eliminate DO demanding materials?) or is Mexican cooperation essential for success of the plan. This seems very risky.

7. **Monitoring Plan.** Regional Board staff will track TMDL implementation, monitor water quality progress, enforce provisions, and propose modifications of the TMDL to the Regional Board if necessary, in accordance with a time schedule. Two types of monitoring will be performed; water quality monitoring, and implementation tracking.

Review. Water Quality Monitoring

The monitoring program is essential to assessing the success of compliance with WQOs - the essentially monthly (presumed) grab sampling program should be enough to address this question as long as the monitoring program addresses sampling properly. The concern here is similar to that expressed above in question 2 where the timing during the day of sampling may influence results, especially the temperature and dissolved oxygen, but also nutrients (N and P are taken up

by algae, both phytoplankton and periphyton, during the day and released at night. Mid-day grab samples will bias results in terms of the loads. A modest investment in continuous monitoring equipment may help fill the gaps by looking a diurnal variations in parameters that can be statistically related to BOD, nutrients, and suspended sediment at a high frequency using the grab samples to provide richer load estimates.

A second purpose for monitoring may be to improve the model calibration (see p. 7) for dissolved oxygen and the DO-demand causing constituents. The model is heavily 'lumped' in that all of the mechanisms that influence the DO were apparently assumed based on experience or the literature (it is never stated how) - since there are at least two constituents of interest that influence DO, namely BOD and ammonia, the minimum calibration that would be expected is for those two (with the possible addition of organic N that is converted to ammonia in the water column). Since ammonia oxidation adds significantly to aeration costs at WWTPs, a better understanding of the profiles of these measures would add considerable credence to the loading estimates.

It is recommended that the Board consider expanding the purpose of the monitoring program - a lot of money is riding on the results.

Under the failure scenarios, the comment that the Board may consider more stringent regulatory mechanisms seems moot since it appears that the Board is already recommending that extraordinary measures are being taken on the U.S. side. It would be helpful to see what those alternative mechanisms might be except for treatment of the river water either off-line or in the river itself.